

# 23: Particles 2: Aerosols

Monday, November 9, 2020 11:55 AM

## Next: How to make or get particles

<http://www.youtube.com/watch?v=DOUfyDHxkYQ&feature=related>

NCFMF film 'Flow Visualization'

Hydrogen bubble technique, but also discusses streamline vs streakline vs pathline

Streamlines  
Tangent to velocity fields

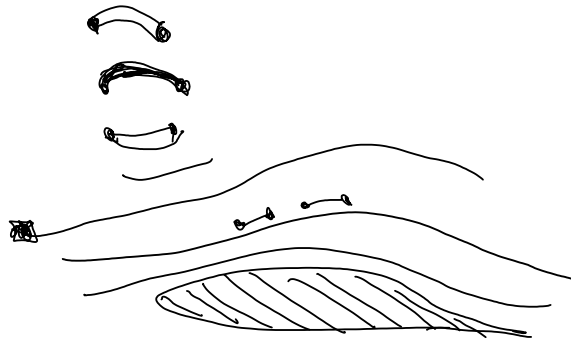
Available in lab

Pathlines  
(path) particle takes

Streaklines  
all particles through 1 point  
STEADY FLOW ALL the SAME

Motion  
Blur  
shows

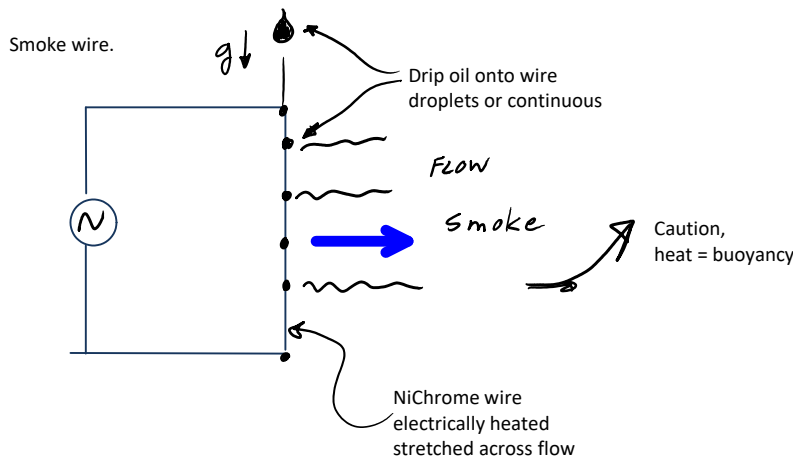
- 99% A) Streamline
- 52% B) Pathline
- 39% C) Streakline

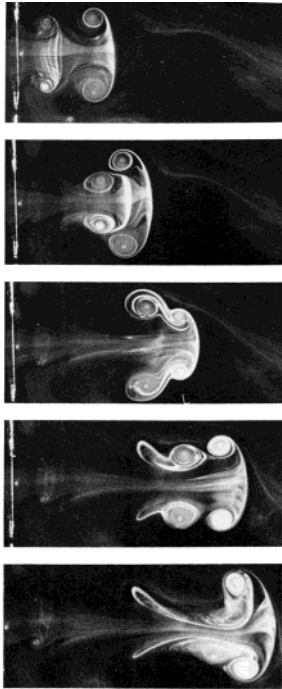


## Aerosols in air: smoke and fog

Solids                      liquids

A) Smoke = soot usually, carbon particles

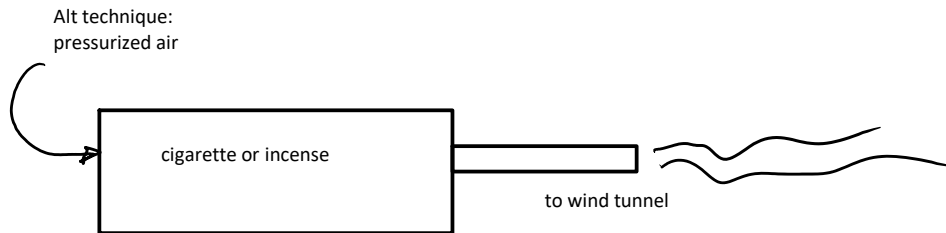




79. Leapfrogging of two vortex rings. Two successive puffs of air are ejected from an orifice of 8 cm diameter by a piston that is driven by the impacts of two pendulums. The flow is made visible by a smoke wire stretched across the orifice, at the left of the photographs. At this Reynolds number of about 1600 based on orifice diameter, the second ring travels faster in the induced field of the first, and has slipped through it in the third photograph. Then the process is reversed, the first ring slipping through the second in the last photograph. Yamada & Matsui 1978

Van Dyke, Milton. *Album of Fluid Motion*. 10th ed. Parabolic Press, Inc., 1982.

Most oils work. Veg is less toxic.  
Generates 1 $\mu$ m particles. Penetrates into lungs, causes cancer, regardless of composition.



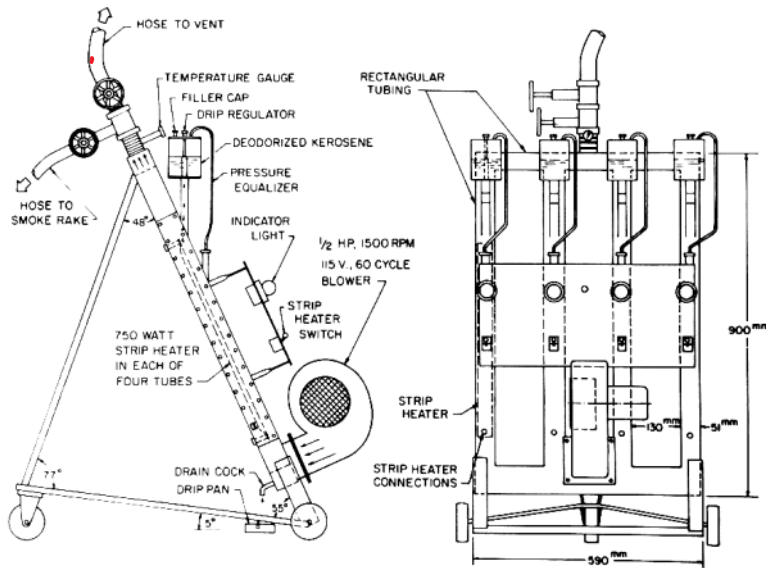
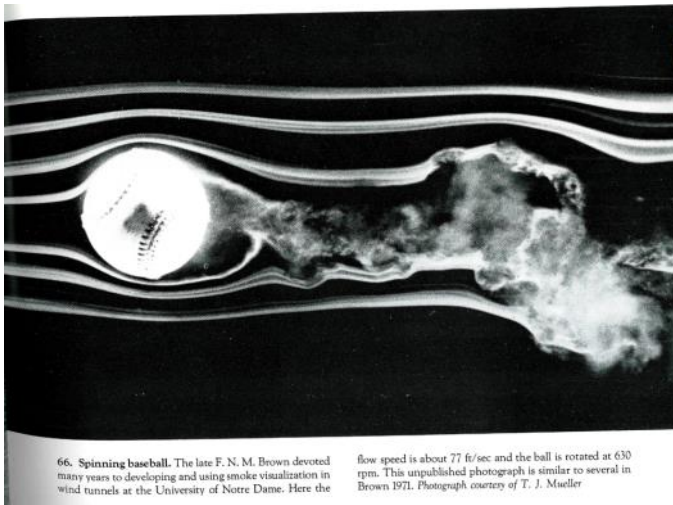


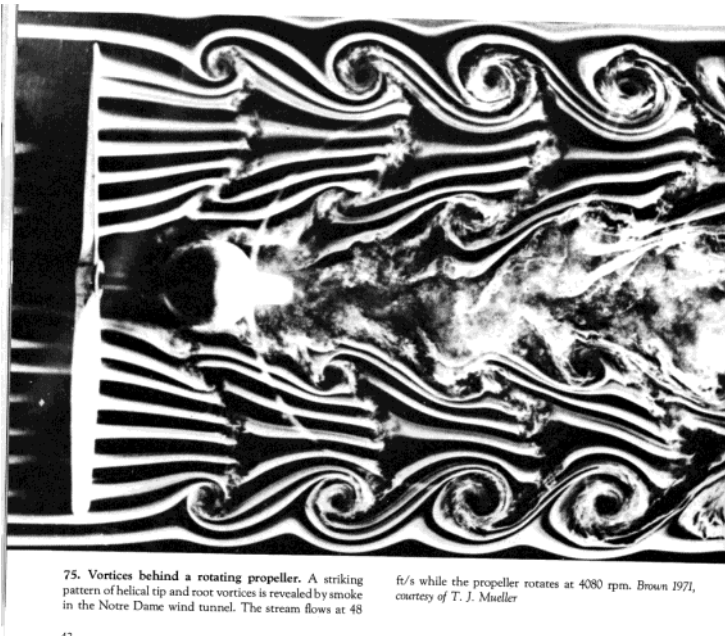
Fig. 2.6 Smoke generator designed at the University of Notre Dame. (From Mueller, 1983. Published by Hemisphere Publishing Corporation.)

Merzkirch, Wolfgang. *Flow Visualization, Second Edition*. 2nd ed. Academic Press, 1987.



66. Spinning baseball. The late F. N. M. Brown devoted many years to developing and using smoke visualization in wind tunnels at the University of Notre Dame. Here the

flow speed is about 77 ft/sec and the ball is rotated at 630 rpm. This unpublished photograph is similar to several in Brown 1971. Photograph courtesy of T. J. Mueller



75. Vortices behind a rotating propeller. A striking pattern of helical tip and root vortices is revealed by smoke in the Notre Dame wind tunnel. The stream flows at 48

ft/s while the propeller rotates at 4080 rpm. Brown 1971, courtesy of T. J. Mueller

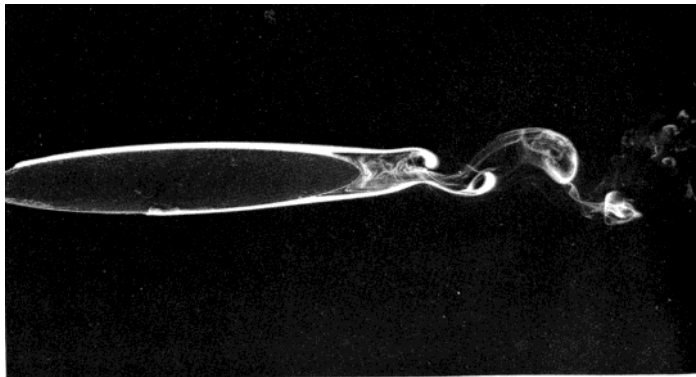
Chemically generated particles:

TiO<sub>2</sub> Titanium dioxide particles from

titanium tetrachloride + water vapor = dense TiO<sub>2</sub> smoke + HCl

HCl + water vapor = hydrochloric acid vapor

Spectacular smoke, but toxic, and hard on equipment, corrosive



32. Laminar separation on a thin ellipse. A 6:1 elliptic cylinder is held at zero angle of attack in a wind tunnel. The Reynolds number is 4000 based on chord. Drops of ti-

tanium tetrachloride on the surface form white smoke, which shows the laminar boundary layer separating at the rear. Bradshaw 1970

## B) Fog = aerosols of liquids

Water fog: Safe, but evaporates quickly

- ultrasonic humidifier [http://www.youtube.com/watch?v=rN-OcMSwS2I&feature=youtu\\_be\\_gdata\\_player](http://www.youtube.com/watch?v=rN-OcMSwS2I&feature=youtu_be_gdata_player)
- [http://www.youtube.com/watch?v=rkrL7tjOlg&feature=youtu\\_be\\_gdata\\_player](http://www.youtube.com/watch?v=rkrL7tjOlg&feature=youtu_be_gdata_player) with acoustic streaming
- medical nebulizer
- dry ice (solid CO<sub>2</sub>)

